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Power Requirements and Costs for High-Capacity Cotton Gins

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CONTENTS

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SUMMARY AND CONCLUSIONS

Total connected loads (total rated horsepower of all electric motors) in high-capacity gins were about 74 percent higher in West Texas and 61 percent higher in California than in conventional gins studied in the same areas during the early 1960's. Operating loads in high-capacity gins were also higher than in conventional gins, but these differences were less than those for connected loads. In West Texas, these differences averaged 29 percent, and in California 14 percent. This indicates that far greater and unnecessary excesses in connected horsepower are incorporated in high-capacity gins than in conventional gins.

The trend to machine harvesting in all areas of the Cotton Belt has shortened the harvest season and placed new demands on cotton gins for higher production rates. To cope with the problem, many firms have added one or more new gins or separate unloading and seed-cotton storage facilities. The latest recommendation for faster unloading and processing is high-capacity ginning.

Installations of larger, faster ginning machinery and equipment generally mean higher total connected loads which, in turn, result in higher electrical energy costs. Therefore, unless increases in ginning rates are sufficient to compensate, power costs per bale will continue to climb as gin plants grow in size.

Objectives of this study were to determine (1) total power requirements, energy consumption, and costs of operating high-capacity gins by specific ginning functions; and (2) differences in total power requirements and costs of operating high-capacity gins and conventional gins.

Information on power requirements and energy consumption was obtained from 17 high-capacity gins in the Midsouth, West Texas, and California. Energy costs per bale were based on average power costs for the season. These data were analyzed for the 10 specific functions performed in cotton gins, and averaged for each of the 3 areas.

Total connected loads for the 17 high-capacity gins ranged from a low of about 625 horsepower for one Midsouth gin to a high of 1,643 horsepower for one California gin. Connected loads averaged 772 horsepower for Midsouth gins, 1,098 horsepower for California gins, and 1,125 horsepower for West Texas plants.

The actual horsepower required for high-capacity gins during normal operation averaged about 490 in the Midsouth, 651 in California, and 639 in West Texas. Average connected loads in high-capacity gins exceeded operating loads by 58, 69, and 76 percent in each of the respective areas. Average idling loads were approximately 85 percent of average operating loads in each area, so, idling, if frequent and for extended periods, can increase costs appreciably.

Energy consumption per bale averaged 47.50 kilowatt-hours in the Midsouth, 52.89 in California, and 55.95 in West Texas. Total energy costs per bale averaged about 98 cents in California, \$1.41 in the Midsouth, and \$1.57 in West Texas.

Average production rates in high-capacity gins exceeded those in conventional gins by about 23 percent in West Texas, and 17 percent in California. Although these were comparable to the differences in operating loads between the two types of gins, the wide spread between connected and operating loads in high-capacity gins resulted in lower motor efficiency and higher energy costs per bale. Differences in energy costs between the two types of gins averaged nearly 16 cents per bale in West Texas, and slightly more than 9 cents per bale in California.

A substantial increase in the use of fans for materials-handling and processing greatly contributed to the greater power requirements and costs for high-capacity gins compared with conventional gins in the two areas. About 12 to 16 percent more fans in high-capacity plants resulted in a difference in fan power requirements of 122 horsepower in California and 135 horsepower in West Texas. As a proportion of the total operating load in high-capacity gins, fans accounted for 66 percent in California and 65 percent in West Texas, compared with 53 percent in conventional gins for the two areas. Differences in costs per bale for fan operations for the two types of gins averaged 18 cents in California and 24 cents in West Texas.

In the high-capacity gins, the five specific functions in gin processing accounted for about two-thirds of the total connected loads, and the five materials-handling functions accounted for the remaining one-third. With respect to energy consumption and costs, processing functions accounted for slightly more than three-fifths of the totals in each area. Considering the 10 functions individually, seed-cotton drying accounted for about 25 percent of the total energy costs per bale. The actual ginning process accounted for another 15 to 20 percent. Unloading seed cotton and trash disposal combined accounted for approximately another 25 percent of total power costs.

This study pointed up five distinct areas of concern for firms considering building a high-capacity gin (1) sharp increases in relative importance of fans to the overall ginning operation and the accompanying increase in power requirements and costs, (2) very small differences between average operating and idling loads, (3) far greater excesses of total connected horsepower than in conventional gins, (4) wide variations in the extent connected load exceeded operating load among ginning functions, and (5) generally minor increases in ginning production rates compared with conventional gins.

POWER REQUIREMENTS AND COSTS FOR HIGH-CAPACITY COTTON GINS

By

Charles A. Wilmot and Harold Watson 1/

INTRODUCTION

Cotton producers expect fast, uninterrupted ginning service throughout the harvest season. When a producer delivers a load of seed cotton to the gin yard, he wants it ginned promptly, and the trailer released for return to the field. Meeting these demands was not too difficult for the ginner so long as harvest rates were fairly constant and predictable. Then he could gear his ginning operation to average daily receipts and usually keep up with the harvest. However, the marked increase in the use of mechanical harvesters in recent years has greatly reduced the length of the harvest season throughout much of the Cotton Belt, and rates of flow of seed cotton to gins have increased rapidly. As the harvest peak approaches, gin yards often become covered with trailers of seed cotton waiting to be ginned.

Ginners have had to explore new means of increasing their production rates. One method commonly employed to increase the production rates is to construct one or more new gins near the existing gin building. Another is to install separate unloading and storage facilities which allow seed cotton to be quickly transferred from the farmers' trailers to baskets or a shed and stored until it can be ginned (11). 2/ An innovation is high-capacity ginning. High-capacity ginning, as used in this report, refers to new gin stands which incorporate either (1) larger diameter gin saws (14-, 16-, or 18-inch diameters instead of the standard 12 inches); (2) a redesigned roll box with reciprocating seed roll action; or (3) dual saw cylinders, and the related materials-handling and processing equipment properly sized for the higher gin stand capacity.

The Problem

Installation of larger, faster ginning machinery and equipment, and the trend to individual drives have resulted in large increases in the electric power loads for operating cotton gins. Three different kinds of power loads are

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2/ Underscored figures in parentheses refer to items in the Bibliography, p. 22.

discussed in this report. Connected load is the rated horsepower of an electric motor; operating load is the actual horsepower used by the motor under load; and idling load is the actual horsepower used when the motor is idling.

In 1945, the average connected horsepower was 185 for California gins and 159 for West Texas gins (5). During succeeding years, more complex unloading systems, additional drying and seed-cotton cleaning equipment, larger feeders and gin stands, and from one to three stages of lint cleaning were gradually incorporated in the normal ginning complement. Line and jack-shaft drives, powered by one or two internal combustion engines or electric motors were gradually replaced by individual electric drives to each piece of equipment. By 1962, total connected loads ranged as high as 857 horsepower in California and 699 in West Texas, and averaged 677 horsepower and 646 horsepower, respectively, for the two areas (18). Since 1962, the horsepower buildup in cotton ginning has continued, with connected loads ranging as high as 1,600 horsepower in single-battery gin plants now being erected.

Although continual increases in total connected horsepower require larger outlays of capital for purchasing electric motors, another major concern of ginners has been the corresponding rise in costs for electrical energy. At given levels of energy consumption, rate structures in most utility schedules favor plants with smaller connected loads and lower kilowatts of demand. Consequently, substantial increases in connected horsepower and in kilowatt-demand loads accompanied by less than proportionate increases in ginning rates have resulted in higher power costs per bale. Unless this imbalance can be corrected, power costs per bale are likely to continue to rise as gins become larger.

Objectives and Method of Study

The objectives of this study were to determine (1) total power requirements, energy consumption, and costs of operating high-capacity gins by specific materials-handling and gin-processing functions; and (2) differences in total power requirements and costs of operating high-capacity gins and conventional gins. 3/

To secure adequate representation of high-capacity gins operating under a wide range of climatic and economic conditions, gins were selected for study in three different producing areas. These areas were the Mississippi Delta, the High Plains of Texas, and the San Joaquin Valley of California, referred to hereafter as Midsouth, West Texas, and California, respectively. In California, wage rates were higher, gin-crew sizes smaller, unit costs for electrical energy lower, and seed-cotton harvesting more completely mechanized than elsewhere in the Cotton Belt. In West Texas, gin-crew sizes were the largest and gin setups the most complex. In the Midsouth, gins were the least complex and wage rates were the lowest of all three areas, but unit electric costs were highest.

A study of at least one complete gin erected by each of the major gin machinery manufacturers in each geographical area was considered essential for adequate coverage. This delayed collecting empirical data because of the slow penetration into two areas by all major companies that manufactured complete high-

3/ Conventional means a standard gin stand with 12-inch saws.

capacity gins. The Midsouth was the first area in which the necessary gin representation was available, and data for this area were collected during the 1962 season. Data collection in West Texas and California could not be completed before 1964. Data were obtained from 17 high-capacity gins.

Readings in volts, amperes, and power factors were made for each individual gin motor. Two sets of readings were taken on each motor at the starter boxes. One reading was made while the motor was idling and another while it was running under a normal operating load. From these readings, kilowatt and horsepower inputs were calculated using the following formulas:

$$Kw = \sqrt{3}\ (E)\ (I)\ (\cos \phi)$$

$$Hp_{3\phi} = kw / 0.746$$

where $\sqrt{3} = 1.73$
E = voltage
I = amperes
$\cos\phi$ = power factor
0.746 = kilowatts per horsepower

In calculating output, input figures were reduced by 15 percent, which is generally accepted as typical of power losses incurred by induction motors, owing to friction and other causes. Energy costs per bale were derived from totals secured either from the ginners or from power companies at the close of the season.

Differences in total power requirements, energy consumption, and costs of operating between high-capacity and conventional gins were determined for two areas--California and West Texas. For this comparison, the data for 11 of the high-capacity gins were compared with the findings of a previous study of 23 conventional gins for the 1961-62 season (18).

Limitations of Study

Opinions differ among ginning engineers as to the proper categorization of certain air fans incorporated in the gin-machinery setup. Some hold that the operation of any fan associated with the movement of seed-cotton, lint, cottonseed, or trash should be charged to materials-handling. Others contend that certain fans are more a part of processing than materials-handling. For example, drier push-pull fans move seed cotton in hot air through an arrangement of drying compartments or chambers to reduce the moisture content in preparation for cleaning. If drying was unnecessary, gin machinery could be so arranged that seed cotton would flow by gravity from the unloading separator through the various stages of cleaning and into the conveyor-distributor, eliminating the need for push-pull fans. Likewise, airblast fans used instead of brushes for doffing of gin saws may also be considered part of the gin stand operation even though they also serve as lint-push fans.

In this study, drier push-pull fans and airblast fans were included under processing rather than materials-handling. In an earlier study of power requirements for all materials-handling in conventional gins, all fans were included under materials-handling (18). Consequently, no direct comparisons of individual materials-handling and gin processing functions between high-capacity and conventional gins could be made, although comparisons of trends in total fan numbers, fan-power requirements, and energy costs were possible.

HIGH CAPACITY--A NEW ERA IN COTTON GINNING

During the past 5 to 10 years, more progress was made in attaining higher ginning rates per gin stand than was made during the previous half century. This marked increase can be attributed mainly to the newly designed high-capacity stands.

Historical Development

From the early 1900's to the late 1950's, 12-inch gin saws were standard in the industry. These saws were rated in capacity at 6 to 12 pounds of ginned lint per hour, depending on local variations in staple lengths, methods of harvesting, and other factors (4).

The ginning rate for a conventional gin was largely dependent on both numbers of saws per stand and number of stands. Attempts to increase total ginning capacities during this period resulted in the gradual replacement of 70-saw gin stands with 80-, 90-, 100-, and finally, 120-saw stands. Likewise, many gins were expanded from 4 to 5 stands, and several to 6 stands per plant. This was about the extent of the progress made by the industry in increasing productivity for several decades.

Much higher ginning rates were achieved in the late 1950's, with the introduction of the high-capacity gin stand. There was no appreciable difference in appearance, overall dimensions, or gin-saw speed in this new type of stand--now offered by each of the major manufacturers. However, rate capabilities were increased up to twice the rates of the preceding models. These pronounced rate increases were achieved by various means. Three manufacturers adopted larger-diameter gin saws. One redesigned the gin-stand roll-box and incorporated a reciprocating action of the seed roll. Another combined the use of two-saw cylinders, thus doubling the number of saws per gin stand without altering the stand length dimensions.

Effect on Complementary Ginning Equipment

Increased rate capabilities of high-capacity gin stands can easily be limited by bottlenecks in complementary ginning equipment. Seed cotton must be supplied to and ginned lint removed from gin stands at adequate rates so as not to impede efficiency. Consequently, the development of high-capacity gin stands required an increase in size of practically every piece of gin equipment including separators, seed-cotton cleaners, distributor-conveyors, feeders, and lint-cleaners. Gin-press rams had to be speeded up and press operations more fully automated to provide faster pressing rates.

In many gins, two separate overhead cleaning systems were installed to supply enough seed cotton to three or more high-capacity gin stands. This required an increase in the number, and in some cases, in the size, of air fans for materials-handling functions. Splitting the stream of seed-cotton flow was handled in several ways. In West Texas, where large volumes of trash were included with seed cotton, two independent unloading and cleaning systems were usually

employed to convey seed cotton from the trailer to the conveyor-distributor. In other areas, only one unloading system was required with the split occurring immediately following the automatic feed control or after the first drier. Splitting the flow of seed cotton doubled the required numbers of machines and equipment. This, plus the use of larger fans, caused substantial increases in operating loads for materials-handling functions.

POWER REQUIREMENTS, ENERGY CONSUMPTION, AND COSTS FOR MATERIALS-HANDLING

Materials-handling in cotton gins included moving seed cotton and lint to the various processing stages, and moving cottonseed and trash to proper collection or disposal facilities. Specific materials-handling functions were (1) seed-cotton unloading, (2) conveying overflow seed cotton, (3) lint conveying, (4) seed conveying, and (5) trash conveying. Each of these functions was generally accomplished pneumatically.

Seed-Cotton Unloading

The seed-cotton unloading system in a typical gin consisted of (1) the unloading or elevator fan, which supplied air of sufficient quantity and velocity to an unloading telescope to remove seed cotton from the trailer by suction (centrifugal fans were used for this); (2) the unloading separator, which separated seed cotton from the conveying air; and (3) an automatic control unit, which consisted of a hopper, two vacuum wheels, and metering device for feeding cotton into the ginning system at desired rates.

Connected loads for the 17 gins with this system ranged from 65 horsepower for one Midsouth gin to 180 horsepower for a West Texas plant (table 1). Connected loads for unloading seed cotton varied with plant layout, rated capacity, and method of harvest. For example, because cotton processed by West Texas gins was stripper-harvested, these plants had a slightly higher average rated capacity than Midsouth or California gins, which processed spindle-harvested cotton.

Operating loads for unloading systems varied in much the same manner as connected loads. Average operating loads ranged from 57.7 horsepower for Midsouth gins to 92.8 horsepower for West Texas plants. Average load requirements for idle operation of unloading systems ranged from 65.4 horsepower for California plants to 88 for West Texas plants. Less power is required to handle a mixture of air and solid material than to handle air alone, which was why average idling loads exceeded average operating loads in two of the three areas.

The wide ranges in idling loads among gins in the same area may have been largely caused by design differences in the automatic feed control. In plants where the fan intake entered an open chamber, so that the fan idled with maximum air intake, high idling loads resulted. In other plants, when cotton was not being unloaded, the fan intake was diverted into a closed chamber. This stopped all airflow through the fan, and greatly reduced the idling power load.

Table 1.--Seed-cotton unloading: Power load, and energy consumption and cost per bale, high-capacity cotton gins in the Midsouth, California, and West Texas, 1962-64 1/

Geographic area	Electric power load			Energy consumption per bale	Energy costs per bale 2/
	Connected	Operating	Idling		
	Hp.	Hp.	Hp.	Kw.-hr.	Ct.
Midsouth					
Range	65.0-110.0	33.7-99.7	39.7-116.7	--	--
Average	79.6	57.9	68.0	5.88	17.46
California					
Range	75.0-130.0	36.6-102.5	30.9-122.2	--	--
Average	95.8	66.2	65.4	5.47	10.19
West Texas					
Range	85.0-180.0	53.4-123.5	37.1-125.4	--	--
Average	130.5	92.8	88.0	8.23	23.04

1/ Includes unloading fan and automatic feed-control unit.

2/ Based on the following typical unit energy costs during the 1964 ginning season: Midsouth--2.97 cents per kw.-hr; California--1.86 cents per kw. hr.; and West Texas--2.80 cents per kw.-hr.

Energy consumption per bale was greater for unloading seed cotton than for any other materials-handling function in West Texas and the Midsouth. The variation in energy consumption was accounted for primarily by differences in operating and idling loads, ginning rate, and operating efficiency (16). Average energy costs per bale for unloading seed cotton ranged from 10.17 cents in California to 23.04 cents in West Texas. In addition to variations in energy used per bale, the wide differences in energy costs per bale for unloading were also affected by variations in electrical rates among areas.

Conveying Overflow Seed Cotton

The overflow conveying system is important for efficient plant operation. A typical system consisted of a centrifugal fan, separator, and conveyor-distributor. For gin stands to operate at maximum efficiency, the input of seed cotton to the conveyor-distributor should slightly exceed the seed-cotton demand of the gin stands. The primary role of the overflow system was to convey the excess seed cotton from the discharge end of the conveyor-distributor back to the input end, where it could be redistributed to the gin stands.

Average connected loads for this system ranged from 28.8 horsepower in the Midsouth to 35.5 horsepower in California (table 2). Two gins in the Midsouth

and one gin in California did not have an overflow system. In these gins, overflow cotton was handled by the unloading system. The automatic feed-control hopper was at the discharge end of the conveyor-distributor, and overflow cotton was returned to this hopper and recirculated back through the entire seed-cotton drying and cleaning systems. Use of the unloading system for handling overflow cotton reduced power and energy requirements. However, recirculating cotton back through the entire seed-cotton conditioning system could adversely affect cotton quality, so this practice is not recommended (13).

Average operating loads for overflow systems ranged from 14.3 horsepower in the Midsouth to 23.9 horsepower in California; average idling loads ranged from 16.4 horsepower in the Midsouth to 25.8 horsepower in California. Compared with unloading, energy consumption per bale for overflow conveying was relatively low, and costs approximated 4 cents a bale.

Lint Conveying

Only the operation of lint-condenser axial fans was charged to lint conveying. These fans constituted the major source of air used for moving ginned lint from gin stands to lint cleaners and to the battery condenser. Additional air for moving lint was generated by the gin stand and lint-cleaner doffing systems, also, but since these sources of air were an integral part of either the gin stand or lint cleaner, it was not possible to separate the power and energy requirements for the two functions.

Connected loads for lint-conveying systems ranged from a low of 25 horsepower for a Midsouth gin to a high of 140 horsepower in a California gin (table 3). Operating loads for this function were affected mainly by the number of lint cleaners. Where unit cleaners were used, a separate exhaust fan was commonly used for each machine. This usually resulted in higher load requirements than for plants of equal capacity that used battery lint cleaners.

Energy requirements for lint-conveying were lowest in the Midsouth and highest in California; however, because of lower electric rates, energy cost per bale was lower in California then the other two areas.

Seed Conveying

Transferring cottonseed from the gin required the least power, energy, and cost for any of the materials-handling functions, and was also the most efficient conveying system within the gin, based on energy cost per pound of materials handled. Seed handling was normally done by a combination of mechanical and pneumatic conveyors. Seed was conveyed mechanically by auger or belt from beneath the gin stands and deposited into a vacuum dropper, which metered it into a pneumatic system for movement to collection or storage areas. The pneumatic segment of this system constituted the major source of power requirements and energy consumption. Positive displacement blowers and small-diameter ducts were used in most gin plants, although centrifugal and large-pipe systems were still used to a limited degree.

Table 2.--Conveying overflow seed cotton: Power load, and energy consumption and cost per bale, high-capacity cotton gins in the Midsouth, California, and West Texas, 1962-64 1/

Geographic area	Electric power load: Connected	Operating	Idling	Energy consumption per bale	Energy costs per bale 2/
	Hp.	Hp.	Hp.	Kw.-hr.	Ct.
Midsouth					
Range	15.0-40.0	8.6-20.2	8.2-23.4	--	--
Average 3/	28.8	14.3	16.4	1.45	4.31
California					
Range	23.0-60.0	15.0-51.7	17.1-49.9	--	--
Average 4/	35.5	23.9	25.8	2.00	3.72
West Texas					
Range	25.5-45.0	12.8-29.2	12.0-19.9	--	--
Average	33.6	18.3	17.1	1.62	4.54

1/ Included overflow fan, separator, and conveyor-distributor.
2/ See footnote 2, table 1.
3/ Based on total of 4 gins with separate overflow systems; gins without separate systems were not included.
4/ Based on total of 5 gins with separate overflow systems; gins without separate systems were not included.

Table 3.--Lint conveying: Power load, and energy consumption and cost per bale, high-capacity gins in the Midsouth, California, and West Texas, 1962-64 1/

Geographic area	Electric power load: Connected	Operating	Idling	Energy consumption per bale	Energy costs per bale 2/
	Hp.	Hp.	Hp.	Kw.-hr.	Ct.
Midsouth					
Range	25.0-90.0	22.3-68.6	24.1-65.7	--	--
Average	44.6	41.2	40.1	4.08	12.12
California					
Range	40.0-140.0	27.4-110.9	30.0-121.8	--	--
Average	76.7	59.3	64.0	4.98	9.26
West Texas					
Range	30.0-110.0	27.0-104.4	24.7-104.8	--	--
Average	64.0	48.1	50.5	4.34	12.15

1/ Included condenser èxhaust fans.

2/ See footnote 2, table 1.

Although low in all areas, energy requirements and costs for conveying cottonseed were higher for Midsouth gins than for gins in the other two areas (table 4). This was because one Midsouth gin used centrifugal fans and large ducts for moving seed rather than positive-displacement blowers and small-diameter ducts. As a result, power requirements in this gin were several times greater than in other Midsouth gins.

Trash Conveying

Trash and foreign matter extracted by the various seed-cotton cleaners, gin stands, and lint cleaners was usually conveyed to disposal areas by centrifugal fans. Load requirements for trash handling, which varied widely among gins in the same area and among areas, depended mainly upon number and type of cleaners employed, type of cotton being processed, and degree to which drier pull-fans were utilized in performing the trash conveying function.

Connected loads for trash conveying averaged from 72.8 horsepower for Midsouth gins to 127.2 horsepower for California gins (table 5). There were similar variations in operating loads.

Based on the amount of trash handled per bale, gins in West Texas should have required more power for trash conveying than gins in the other two areas. Instead, 27 percent more power was required for trash handling in California than in West Texas. This may be attributed mainly to the more efficient use of drier pull fans for handling trash removed by seed-cotton cleaners in West Texas.

Average energy cost per bale for trash handling was lower in California than in the other two areas. However, in California, cost of this function was higher than for any of the other four materials-handling functions. In the Midsouth and West Texas, trash conveying was the second most costly materials-handling function.

Materials-Handling Functions Combined

Connected loads for all materials-handling ranged from 157.5 horsepower for one Midsouth gin to 597.5 horsepower for one California plant (table 6). Average connected and average operating loads for all materials-handling for both California and West Texas were about 35 to 45 percent greater than for the Midsouth. Average energy consumption in California and West Texas exceeded the Midsouth average by only about 15 to 20 percent. However, because of the differences in unit cost of electricity, average costs per bale for materials-handling in West Texas and the Midsouth were about 40 to 55 percent higher than the average cost in California.

POWER REQUIREMENTS, ENERGY CONSUMPTION, AND COSTS FOR GIN PROCESSING

Processing functions in cotton gins may be subdivided into (1) seed-cotton drying, (2) seed-cotton cleaning, (3) ginning, (4) lint cleaning, and (5) packaging.

Table 4.--Seed conveying: Power load, and energy consumption and cost per bale, high-capacity cotton gins in the Midsouth, California, and West Texas, 1962-64 1/

Geographic area	Electric power load: Connected	Electric power load: Operating	Electric power load: Idling	Energy consumption per bale	Energy costs per bale 2/
	Hp.	Hp.	Hp.	Kw.-hr.	Ct.
Midsouth					
Range	15.0-43.0	8.6-31.8	5.1-35.2	--	--
Average	24.7	13.5	11.4	1.31	3.89
California					
Range	10.0-35.0	7.1-12.3	2.8-8.2	--	--
Average	22.6	9.2	6.2	.73	1.36
West Texas					
Range	10.5-38.0	3.1-11.1	1.5-7.1	--	--
Average	24.2	7.5	4.8	.63	1.76

1/ Included seed conveyor under gin stands, vacuum dropper, and blower or fan.
2/ See footnote 2, table 1.

Table 5.--Trash conveying: Power load, and energy consumption and cost per bale, high-capacity cotton gins in the Midsouth, California, and West Texas, 1962-64 1/

Geographic area	Electric power load: Connected	Electric power load: Operating	Electric power load: Idling	Energy consumption per bale	Energy costs per bale 2/
	Hp.	Hp.	Hp.	Kw.-hr.	Ct.
Midsouth					
Range	20.0-120.0	17.0-108.1	17.0-107.6	--	--
Average	72.8	52.3	50.1	5.16	15.33
California					
Range	58.0-235.0	29.4-211.7	30.0-223.5	--	--
Average	127.2	90.0	93.3	7.50	13.95
West Texas					
Range	75.0-156.0	50.9-86.7	52.2-83.1	--	--
Average	111.2	70.7	68.1	6.28	17.58

1/ Included conveyor and fans devoted specifically to trash conveying, and did not include dry pull-fans although these fans conveyed trash.
2/ See footnote 2, table 1.

Seed-Cotton Drying

Seed-cotton drying is the only pneumatically operated processing function. Drying is accomplished by exposing seed cotton to relatively large volumes of heated air supplied by the use of centrifugal fans. A modern gin usually employs two stages of drying. Each drying stage consists of a heating unit, a tower or reel drier, and two fans, one pushing and the other pulling heated air through the system. The pull fan takes in air through a seed-cotton cleaner, which allows trash removed by this cleaner to be handled with this fan.

The condition of seed cotton has little effect on power requirements for performing this function. Even if artificial drying is not required and no heat is applied, as is often true in California, seed cotton is still directed through the drying system, requiring the continued use of the drier fans.

Load requirements, energy consumption, and energy cost for drying were the highest for any single function within the various gin plants (table 7). On an average, drying accounted for 25 to 30 percent of the total electric power load, and of the total energy consumption and cost for operating high-capacity gins. In West Texas, the energy cost for drying was approximately double the second most costly function. Energy consumption per bale for drying did not differ appreciably among areas compared with the wide variation in average costs.

Variations observed in operating loads and in energy requirements per bale among areas, and among gin plants within the same area, were due primarily to differences in plant layout or design and in volumes of air handled. Differences in ginning rates could also be a slight contributing factor to these variations.

Seed-Cotton Cleaning

Numbers and types of machinery combinations for seed-cotton cleaning are almost as varied as the number of gin plants. A typical machinery combination for machine-harvested cotton includes a minimum of 14 cylinders of cleaning, and two extracting units such as the stick remover, bur machine, or extractor-feeder. In West Texas and other stripper-harvest areas, additional cleaners are normally employed in gins.

Connected loads for cleaning were equal to only half or less of the connected load for drying, and operating loads for cleaning were about a fifth to a third of the operating loads for drying (table 8). Operating loads, and energy consumption and cost for drying in West Texas were approximately double those in the other two areas. This was because of the larger volumes of seed cotton required to yield a bale of ginned lint, and the more elaborate machinery combinations necessary to achieve sufficient cleaning of the stripper-harvested cotton in this area.

Ginning

Separation of fibers from seeds in the gin stands is the basic processing operation of a cotton gin, and plant capacity is dependent primarily on the number, size, and efficiency of the stands. Capacities of individual stands now

Table 6.--All materials-handling: Power load, and energy consumption and cost per bale, high-capacity cotton gins in the Midsouth, California, and West Texas, 1962-64 1/

Geographic area	Electric power load: Connected	Electric power load: Operating	Electric power load: Idling	Energy consumption per bale	Energy costs per bale 2/
	Hp.	Hp.	Hp.	Kw.-hr.	Ct.
Midsouth					
Range	157.5-317.5	125.0-271.6	122.0-283.5	--	--
Average	250.5	179.0	186.0	17.88	53.11
California					
Range	250.5-597.5	178.1-485.6	167.3-523.2	--	--
Average	357.8	248.6	254.7	20.68	38.46
West Texas					
Range	305.0-516.0	174.3-350.3	151.4-339.1	--	--
Average	363.5	237.4	228.5	21.10	59.07

1/ Included seed cotton, unloading, conveying, overflow, seed cotton, and trash.
2/ See footnote 2, table 1.

Table 7.--Seed cotton drying: Power load, and energy consumption and cost per bale, high-capacity cotton gins in the Midsouth, California, and West Texas, 1962-64 1/

Geographic area	Electric power load: Connected	Electric power load: Operating	Electric power load: Idling	Energy consumption per bale	Energy costs per bale 2/
	Hp.	Hp.	Hp.	Kw.-hr.	Ct.
Midsouth					
Range	120.0-210.0	95.6-160.9	91.8-177.8	--	--
Average	163.3	119.4	130.8	12.03	35.73
California					
Range	195.0-355.0	128.1-285.6	148.8-307.6	--	--
Average	254.9	172.7	191.9	14.56	27.08
West Texas					
Range	220.0-410.5	126.8-222.5	131.1-236.3	--	--
Average	280.6	176.4	187.2	15.91	44.55

1/ Included dry and moisture-restoration fans, and reel or trough driers, where used.
2/ See footnote 2, table 1.

range from 3.5 to 7 bales per hour, compared with an average of about 1.5 to 2 bales per hour for a conventional 90-saw gin stand operating at peak performance.

Measurement of gin-stand operating loads, which are extremely variable within a given plant, depending upon the ginning rate, were made while the stands were ginning at approximately rated capacity (18). Average operating loads for gin stands were the second highest for any of the 10 individual functions (table 9). Average energy consumption and costs for gin stand operations also ranked second, except in West Texas. In this area, average energy required for unloading seed cotton, and its average costs, were both slightly greater than comparable averages for operating the gin stands.

Lint Cleaning

Most high-capacity gin plants employ two stages of saw-type lint cleaning for combing and removal of trash from the ginned cotton fibers, and some plants have three stages. Both unit and battery or bulk-type cleaners are used, with the trend being toward the unit-machine.

Total connected loads for lint-cleaning averaged 75.8 horsepower in the Midsouth to 114.2 horsepower in California (table 10). Operating load requirements, which may vary widely depending upon processing rates, ranged from a low of 31.5 horsepower in one Texas plant to a high of 108.2 horsepower in another Texas plant. On an average, the energy required per bale and its cost for lint-cleaning was equal to about half of the energy requirements and costs for operating gin stands.

Packaging

The packaging system comprises the battery condenser, tramper, press, and press pump. Presses used in all gins studied were the flat-bale type. Both up-packing and down-packing presses were represented. Average connected loads for packaging ranged from 45.0 horsepower in the Midsouth to 74.7 horsepower in California (table 11).

Average operating power loads for packaging are practically meaningless, except for computing energy requirements and costs, because operating loads on tramper and press pump motors are not constant, but gradually build up as the peak of the packaging cycle approaches. Because of the high variability in operating loads during pressing and tramping, these loads were not measured at each gin. Instead, kilowatt-hour meters and timeclocks were installed in four Midsouth plants, where energy requirements and machine operating time were monitored for the entire ginning season. From these data, load requirements, and energy consumption and costs were estimated for each of the three areas. Packaging was the least costly of the 5 processing functions, and for all 10 functions, only seed conveying was less costly.

Table 8.--Seed-cotton cleaning: Power load, and energy consumption and cost per bale, high-capacity cotton gins in the Midsouth, California, and West Texas, 1962-64 1/

Geographic area	Electric power load			Energy consumption per bale	Energy costs per bale 2/
	Connected	Operating	Idling		
	Hp.	Hp.	Hp.	Kw.-hr.	Ct.
Midsouth					
Range	55.0-150.0	16.7-48.8	9.0-41.7	--	--
Average	82.0	28.5	19.0	2.69	7.99
California					
Range	70.0-120.0	18.3-61.0	11.1-45.8	--	--
Average	88.9	31.8	22.9	2.52	4.69
West Texas					
Range	87.5-180.0	39.6-97.0	15.4-78.6	--	--
Average	142.5	55.9	40.3	4.79	13.41

1/ Included all seed-cotton cleaners, with the exception of reel or trough driers, where used.
2/ See footnote 2, table 1.

Table 9.--Ginning: Power load, and energy requirements and cost per bale, high-capacity cotton gins in the Midsouth, California, and West Texas, 1962-64 1/

Geographic area	Electric power load			Energy consumption per bale	Energy costs per bale 2/
	Connected	Operating	Idling		
	Hp.	Hp.	Hp.	Kw.-hr.	Ct.
Midsouth					
Range	100.0-210.0	49.4-129.4	20.8-69.0	--	--
Average	155.0	100.4	41.1	9.08	26.97
California					
Range	150.0-300.0	81.7-185.6	35.1-69.0	--	--
Average	207.5	121.2	45.7	9.11	16.94
West Texas					
Range	150.0-240.0	71.7-123.2	24.5-90.2	--	--
Average	194.0	99.6	44.0	8.16	22.85

1/ Included gin stands, and air-blast fan where used.
2/ See footnote 2, table 1.

Table 10.--Lint cleaning: Power load, and energy consumption and cost per bale, high-capacity cotton gins in the Midsouth, California, and West Texas, 1962-64 1/

Geographic area	Electric power load			Energy consumption per bale	Energy costs per bale 2/
	Connected	Operating	Idling		
	Hp.	Hp.	Hp.	Kw.-hr.	Ct.
Midsouth					
Range	60.0-90.0	38.2-56.5	9.6-38.3	--	--
Average	75.8	45.7	26.9	4.26	12.65
California					
Range	75.0-200.0	43.9-94.3	19.5-61.2	--	--
Average	114.2	60.5	33.4	4.68	8.70
West Texas					
Range	50.0-175.0	31.5-108.2	21.5-88.6	--	--
Average	90.0	53.4	38.9	4.58	12.82

1/ Includes lint cleaners only.
2/ See footnote 2, table 1.

Table 11.--Packaging: Power load, and energy requirements and cost per bale, high-capacity cotton gins in the Midsouth, California, and West Texas, 1962-64 1/

Geographic area	Electric power load			Energy consumption per bale 2/	Energy costs per bale 3/
	Connected	Operating 2/	Idling		
	Hp.	Hp.	Hp.	Kw.-hr.	Ct.
Midsouth					
Range	37.0-57.0	--	7.4-17.5	--	--
Average	45.0	16.6	10.5	1.56	4.63
California					
Range	53.0-87.0	--	8.9-20.0	--	--
Average	74.7	16.6	13.5	1.34	2.49
West Texas					
Range	42.0-82.0	--	9.2-16.2	--	--
Average	54.4	16.6	11.4	1.41	3.95

1/ Includes condenser, tramper, press, and press pump.
2/ Based on seasonal average data obtained with kw.-hr. meters and timeclock installations in Midsouth gins; no range indicated. California and Midsouth gins were not monitored.
3/ See footnote 2, table 1.

Processing Functions Combined

The average connected load for all gin-processing functions accounted for approximately two-thirds of the total connected load of high-capacity gins in all three areas. Processing accounted for about three-fifths of the total operating loads, energy consumption, and energy costs in these gins.

For all gin processing, there were only relatively small differences among areas in average energy consumption per bale--from about 30 to 35 kilowatt-hours (table 12). However, the important effect of electrical rates on ginning costs is reflected by the relatively large differences among areas in average energy costs per bale. For processing, these costs ranged from about 60 cents in California to about $1 in West Texas.

TOTAL POWER REQUIREMENTS, ENERGY CONSUMPTION, AND COSTS FOR HIGH-CAPACITY GINS

Total connected loads for California and West Texas plants, which averaged 1,098.0 and 1,125.0 horsepower, respectively, were substantially higher than those for Midsouth plants, which averaged 771.6 horsepower (table 13). Variations in operating and idling loads among areas were in about the same proportions.

Total energy consumption was also lower in the Midsouth than in the other two areas. However, energy costs per bale were slightly lower than $1 in California, compared with about $1.41 and $1.57 in the Midsouth and West Texas, respectively. The wide variations in unit energy costs among areas, favoring gins in California, accounted for the inconsistent relationships between energy consumption and costs among areas.

On an average, total connected loads exceeded operating loads by 58, 69, and 76 percent in the Midsouth, California, and West Texas, respectively (table 14). Overmotoring was more prevalent for processing than for materials-handling in each area, although, there were wide variations in the extent of overmotoring among ginning functions and areas. 4/ For example, in the Midsouth average connected load for lint conveying exceeded average operating load by only 8 percent, while for seed-cotton cleaning there was an excess of 188 percent.

Average operating loads exceeded average idling loads by only about 75 horsepower in the Midsouth and 89 horsepower in both California and West Texas, (table 13). With idling loads averaging approximately 85 percent of operating loads, extended periods of idling can be very costly.

Other research has shown that the break-even idling time for the average high-capacity gin plant is approximately 16.5 seconds (17). In deriving this figure, consideration was given only to energy consumption and energy cost for starting the plant as compared to the per minute cost for idling operation. If approximately 1 minute was allowed for stopping and restarting, maximum idling

4/ Overmotoring is another term for excess connected horsepower.

Table 12.--All processing: Power load, and energy consumption and cost per bale, high-capacity cotton gins in the Midsouth, California, and West Texas, 1962-64 1/

Geographic area	Electric power load: Connected	Electric power load: Operating	Electric power load: Idling	Energy consumption per bale	Energy costs per bale 2/
	Hp.	Hp.	Hp.	Kw.-hr.	Ct.
Midsouth					
Range.........	462.0-697.0	233.4-392.8	179.6-330.9	--	--
Average.......	521.1	310.6	228.3	29.62	87.97
California					
Range.........	598.0-1045.5	310.5-645.9	238.6-492.5	--	--
Average.......	740.2	402.8	307.4	32.21	59.90
West Texas					
Range.........	634.5-918.5	344.5-450.5	213.7-382.6	--	--
Average.......	761.5	401.9	321.8	34.85	97.58

1/ Includes drying and cleaning seed cotton, ginning, lint cleaning, and packaging.
2/ See footnote 2, table 1.

time should not exceed 1.25 minutes. Additional time might have to be allowed for drier warm-up, depending upon conditions prevailing at the time.

HIGH-CAPACITY GINS COMPARED WITH CONVENTIONAL GINS

Differences in Power Requirements and Costs

Total connected loads in high-capacity gins averaged 74 percent and 61 percent higher than those in conventional gins in West Texas and California, respectively (table 15). Operating loads in high-capacity gins were also greater than those in conventional gins in both areas. However, these differences were much narrower, with operating loads in high-capacity gins exceeding those in conventional gins by an average of only 29 percent in West Texas and 14 percent in California. This indicates that, in general, far greater excesses in connected horsepower are being prescribed for high-capacity gin plants than was true for electrically-operated conventional gins.

Prescribing excess connected horsepower, while necessary in certain situations due to the inflexibility of motor sizes, appears to be a carryover from the days when gins were powered by internal combustion engines (19). Internal

Table 13.--Total power load, and energy consumption and cost per bale, by ginning function, high-capacity cotton gins in the Midsouth, California, and West Texas, 1962-64

Geographic area and function	Electric power load: Connected	Electric power load: Operating	Electric power load: Idling	Energy consumption per bale	Energy costs per bale 1/
	Hp.	Hp.	Hp.	Kw.-hr.	Ct.
Midsouth					
Unloading	79.6	57.7	68.0	5.88	17.46
Operating overflow	28.8	14.3	16.4	1.45	4.31
Lint conveying	44.6	41.2	40.1	4.08	12.12
Seed conveying	24.7	13.5	11.4	1.31	3.89
Trash disposal	72.8	52.3	50.2	5.16	15.33
Total	250.5	179.0	186.0	17.88	53.11
Seed cotton drying	163.3	119.4	130.8	12.03	35.73
Seed cotton cleaning	82.0	28.5	19.0	2.69	7.99
Ginning	155.0	100.4	41.1	9.08	26.97
Lint cleaning	75.8	45.7	26.9	4.26	12.65
Packaging	45.0	16.6	10.5	1.56	4.63
Total	521.1	310.6	228.3	29.62	87.97
All functions	771.6	489.6	414.3	47.50	141.08
California					
Unloading	95.8	66.2	65.4	5.47	10.17
Operating overflow	35.5	23.9	25.8	2.00	3.72
Lint conveying	76.7	59.3	64.0	4.98	9.26
Seed conveying	22.6	9.2	6.2	.73	1.36
Trash disposal	127.2	90.0	93.3	7.50	13.95
Total	357.8	248.6	254.7	20.68	38.46
Seed cotton drying	254.9	172.7	191.9	14.56	27.08
Seed cotton cleaning	88.9	31.8	22.9	2.52	4.69
Ginning	207.5	121.2	45.7	9.11	16.94
Lint cleaning	114.2	60.5	33.4	4.68	8.70
Packaging	74.7	16.6	13.5	1.34	2.49
Total	740.2	402.8	307.4	32.21	59.90
All functions	1,098.0	651.4	562.1	52.89	98.36
West Texas					
Unloading	130.5	92.8	88.0	8.23	23.04
Operating overflow	33.6	18.3	17.1	1.62	4.54
Lint conveying	64.0	48.1	50.5	4.34	12.15
Seed conveying	24.2	7.5	4.8	.63	1.76
Trash disposal	111.2	70.7	68.1	6.28	17.58
Total	363.5	237.4	228.5	21.10	59.07
Seed cotton drying	280.6	176.4	187.2	15.91	44.55
Seed cotton cleaning	142.5	55.9	40.3	4.79	13.41
Ginning	194.0	99.6	44.0	8.16	22.85
Lint cleaning	90.0	53.4	38.9	4.58	12.82
Packaging	54.4	16.6	11.4	1.41	3.95
Total	761.5	401.9	321.8	34.85	97.58
All functions	1,125.0	639.3	550.3	55.95	156.65

1/ See footnote 2, table 1.

Table 14.--Extent connected loads exceeded operating loads for materials handling and processing functions in 17 high-capacity cotton gins in the Midsouth, California, and West Texas, 1962-64

Functions	Extent of overmotoring 1/		
	Midsouth	California	West Texas
	Percent	Percent	Percent
Materials handling			
Unloading	38	45	41
Operating overflow	101	49	84
Lint conveying	8	29	33
Seed conveying	83	146	223
Trash disposal	39	41	57
Average	40	44	53
Processing			
Seed cotton drying	37	48	59
Seed cotton cleaning	188	180	155
Ginning	54	71	95
Lint cleaning	66	89	69
Packaging	2/ 171	2/ 350	2/228
Average	68	84	89
Average, all functions	58	69	76

1/ Overmotoring is another term for excess connected horsepower.
2/ Based on seasonal average data obtained with kw.-hr. meters and timeclocks in 4 Midsouth gins only. These figures are almost meaningless, because operating loads on tramper and press pump motors from which they were derived are not constant but gradually build up as the peak of the packaging cycle approaches.

combustion engines normally should be operated somewhere between 70 and 90 percent of full load for maximum efficiency. Therefore, excess capacity is desirable when this source of power is employed. However, efficiency curves for electric motors show that peak performance is attained right at full load. Unfortunately, this important difference between these two types of power sources is apparently disregarded, and overmotoring in present-day all-electric gin plants appears to be increasing instead of diminishing.

Another reason for prescribing and using oversized motors is to provide an extra margin of assurance that the equipment will operate continuously without stoppages due to lack of power. This results not only in higher initial capital outlays, since the cost and size of electric motors of a given type are directly proportional, but in higher energy consumption and costs as well. Differences in energy consumption per bale between high-capacity and conventional gins was appreciably greater in California than in West Texas. However, because of the lower cost of electricity in California, differences in energy costs per bale between the two types of gins were less there than in West Texas.

Table 15.--Average connected and operating loads, and average energy consumption and cost for 11 high-capacity gins in California and West Texas, 1964, and for 23 conventional gins in California and West Texas, 1961-62 1/

Geographic area and type of gin	Load type: Connected	Load type: Operating	Energy consumption per bale	Energy costs per bale
	Hp.	Hp.	Kw.-hr.	Ct.
California				
High-capacity gins	1098.0	651.4	52.89	2/ 98.36
Conventional gins	677.0	571.0	47.68	3/ 89.00
Difference 4/				
Total	421.0	80.4	5.21	9.36
Percent	61	14	11	11
West Texas				
High-capacity gins	1125.0	639.3	55.95	2/ 156.65
Conventional gins	646.0	495.0	54.31	3/ 141.00
Difference 4/				
Total	479.0	144.3	1.64	15.65
Percent	74	29	3	11

1/ Conventional gins were equipped with standard gin stands with 12-inch saws.
2/ See footnote 2, table 1.
3/ Based on the following typical unit energy cost for conventional gins during the 1962 ginning season: California--1.86 cents per kw.-hr.; West Texas--2.62 cents per kw.-hr.
4/ In all cases, indicates the extent high-capacity gins were greater than conventional gins.

Table 16.--Average number of fans, fan operating loads, and energy requirements and costs for 11 high-capacity gins in California and West Texas, 1964, and for 23 conventional gins in California and West Texas, 1961-62 1/

Type of gin and geographic area	Fans per gin	Fan operating load: Total per gin	Fan operating load: Proportion of total operating load	Energy consumption per bale	Energy cost per bale
	No.	Hp.-hr.	Pct.	Kw.-hr.	Ct.
High-capacity gins					
California	18.0	427	66	35.2	2/ 0.65
West Texas	18.2	398	63	35.4	2/ .99
Conventional gins 3/					
California	16.1	305	53	25.5	4/ .47
West Texas	15.7	263	53	28.9	4/ .75

1/ Conventional gins were equipped with standard gin stands with 12-inch saws.
2/ See footnote 2, table 1. 3/ Source: (21).
4/ Based on the following typical unit energy cost for conventional gins during the 1962 ginning season: California--1.86 cents per kw.-hr.; West Texas--2.62 cents per kw.-hr.

Increase in Use of Fans

Greater use of fans was a major factor accounting for the greater power requirements and costs in high-capacity gins. On an average, there were about 18 fans in high-capacity gins in both California and West Texas (table 16). In comparison, conventional gins studied in 1961-62 had about 16 fans per plant (18).

Horsepower required for operating all fans in high-capacity gins exceeded that needed in conventional gins by 40 percent in California, and about 50 percent in West Texas. Fans accounted for almost two-thirds of the total operating loads for high-capacity plants, compared with slightly more than half of the total in conventional gins.

Energy consumption for fans in high-capacity gins was about 38 percent greater than for conventional gins in California, and 22 percent greater in West Texas. Although there was practically no difference in fan energy consumption per bale in high-capacity gins between the 2 areas, energy costs for fan operations in West Texas gins were about 52 percent greater than the cost in California gins. Costs per bale for energy to operate fans in high-capacity gins averaged 65 cents in California and 99 cents in West Texas. Compared with the 1961-62 study of conventional gins, these costs were 18 cents greater in California and 24 cents greater in West Texas.

As a result of the greater use of fans, operating loads in high-capacity gins were about 10 and 13 percent greater than in conventional gins in West Texas and California, respectively. These differences should be carefully considered by cost-conscious ginners, because pneumatic conveying systems for materials-handling have long been known for inefficient power use. Ginning research engineers are working to alleviate this problem (1, 3). General suggestions for increasing the efficiency of materials handling include (1) peaking efficiency of individual air systems, (2) rearranging gin machinery to reduce number of fans necessary, and (3) incorporating new engineering principles (18). Eventually such items as the suction pipe may be completely outmoded (12). However, until real progress is made in the development and adoption of power-saving conveying techniques, further increases in the numbers of fans and total gin operating loads appear likely, if gin plants continue to grow in size.

Differences in Rates of Ginning

The average hourly ginning rate for high-capacity gins in California was 10.65 bales compared with 9.03 bales for conventional, or 17 percent higher. In West Texas, the average hourly rate of 9.86 bales for high-capacity gins was 23 percent higher than the average conventional rate of 7.96 bales. These differences in ginning rates were much smaller than the differences in total connected loads between the two types of gins, which averaged 61 percent in California and 74 percent in West Texas.

Differences in average operating loads were quite similar to the differences in average ginning rates, ranging from 14 percent higher in high-capacity gin plants in California to 29 percent higher in West Texas high-capacity gins. However, the wide spread between connected loads and operating loads resulted in lower motor efficiencies and higher energy costs per bale in both areas.

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